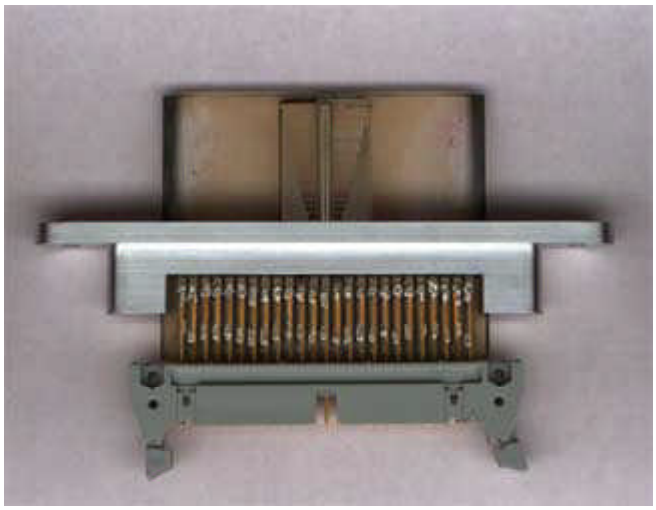
Thermocouple Rakes for Measuring Boundary Layer Flows Extremely Close to Surface

Of vital interest to aerodynamic researchers is precise knowledge of the flow velocity profile next to the surface. This information is needed for turbulence model development and the calculation of viscous shear force. Though many instruments can determine the flow velocity profile near the surface, none of them can make measurements closer than approximately 0.01 in. from the surface. The thermocouple boundary-layer rake can measure much closer to the surface than conventional instruments can, such as a total pressure boundary layer rake, hot wire, or hot film.

By embedding the sensors (thermocouples) in the region where the velocity is equivalent to the velocity ahead of a constant thickness strut, the boundary-layer flow profile can be obtained. The present device fabricated at the NASA Glenn Research Center microsystem clean room has a heater made of platinum and thermocouples made of platinum and gold. Equal numbers of thermocouples are placed both upstream and downstream of the heater, so that the voltage generated by each pair at the same distance from the surface is indicative of the difference in temperature between the upstream and downstream thermocouple locations. This voltage differential is a function of the flow velocity, and like the conventional total pressure rake, it can provide the velocity profile. In order to measure flow extremely close to the surface, the strut is made of fused quartz with extremely low heat conductivity. A large size thermocouple boundary layer rake is shown in the following photo.

The latest medium size sensors already provide smooth velocity profiles well into the boundary layer, as close as 0.0025 in. from the surface. This is about 4 times closer to the surface than the previously used total pressure rakes. This device also has the advantage of providing the flow profile of separated flow and also it is possible to measure simultaneous tur-bulence levels within the boundary layer.



Large thermocouple boundary layer rake.

Find out more about this research (http://www.grc.nasa.gov/WWW/microblowing/).

Bibliography

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Hwang, Danny P.; Will, Herbert A.; and Fralick, Gustave C.: Thermocouple Rakes for Measuring Boundary-Layer Flows. NASA Tech Brief LEW-16999-1, Aug. 10, 2000.

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